

March 28, 1985

Final Report

PREDICTION OF THE DYNAMIC RESPONSE OF RISERS AND CABLES

Contract No. N00014-84-C-2043

Submitted to:

Dr. Owen Griffin
Marine Technology Division
Code 5841
Naval Research Laboratory
Washington, D.C. 20375

Submitted by:

Professor J. Kim Vandiver
Massachusetts Institute of Technology
Room 5-222
Cambridge, MA 02139

Introduction

The purpose of this work was to develop models for the prediction of non-lockin response of long flexible cylinders to flow-induced lift and drag forces. The statement of work included two specific research tasks.

1. Develop a lift coefficient prediction model, using the wake oscillator concept. This concept has been used to estimate the lift coefficient from cylinder response for the lockin case. Wake oscillator model equations can be utilized if it is assumed that the cylinder response is a Gaussian random process under non-lockin conditions. Evaluation of previous experimental data confirms this assumption.
2. Investigate the non-linear correlation between in-line and cross-flow vibration. Use bi-spectral analysis techniques to investigate the properties of a quadratic relationship between lift and drag excitation. Develop a non-lockin random process model of the lift and drag excitation on long cylinders which includes quadratic properties revealed during the course of the research.

Both tasks have been completed. A Ph.D. dissertation by Jen-Yi Jong is the principal archival document which presents the details of the research. Two journal articles based on the research will be produced in the coming months. A brief review of the key results is given below.

The Wake Oscillator Model for the Non-Lockin Case

A manuscript on the subject has been previously sent to you. Though we were able to obtain solutions for the non-lockin case, using the concept of the wake oscillator, we feel the wake oscillator model for non-lockin conditions has very limited usefulness and we do not intend to pursue its application. The quadratic system models proposed in Task 2 have much greater promise and are far less computationally cumbersome to work with. The results of the bi-spectrum work indicate that in-line and cross-flow vibration are highly correlated but with a non-linear relationship. Therefore, proper use of wake oscillator models would require the use of separate in-line and cross-flow models which are non-linearly correlated. This would be very difficult to do.

Bi-Spectrum Analysis and Quadratic Systems Identification

The basic research has been completed in the form of a Ph.D. dissertation by Jen-Yi Jong, which has been previously submitted to you. For reference purposes, the thesis is Jong, Jen-Yi, Ph.D. Dissertation: "The Quadratic Correlation Between In-Line and Cross-Flow Vortex-Induced Vibration of Long Flexible Cylinders," MIT Department of Ocean Engineering, Report No. 84-10, August 1984; supervised by Prof. J. Kim Vandiver.

The principal results are summarized below:

1. In-line and cross-flow response are not independent processes for either lockin or non-lockin cases. The results of bi-spectral analysis indicate that these geometrically perpendicular responses are quadratically correlated to one another.
2. Non-linear correlations higher than second order are negligible in both lockin and non-lockin conditions.
3. Quadratic system models have been identified that can be used to predict in-line motions given the cross-flow motions as inputs.

The bi-spectrum analysis results and the quadratic system identification have been submitted for review and eventual publication.

Our other research on flow-induced vibration has been progressing well and is summarized here for your information. A Ph.D. dissertation by Yang-Hann Kim, "Vortex-Induced Response and Drag Coefficients of Long Cables in Ocean Currents", MIT Department of Ocean Engineering, October 1984, supervised by Prof. J. Kim Vandiver. This work was condensed into a paper which was recently presented at an ASME conference and has been accepted for publication in the Journal of Energy Resources Technology. This paper is: Kim, Y.H., Vandiver, J.K., and Holler, R., "Vortex-Induced Vibration and Drag Coefficients of Long Cables Subjected to Sheared Flows," Proc. 4th International Offshore Mechanics and Arctic Engineering Symposium, ASME, Dallas, February 1985.

A new paper on response prediction will be presented at the 1985 OTC. It is: Vandiver, J.K., "Prediction of Lockin Vibration on Flexible Cylinders in Sheared Flow," Proc. 1985 Offshore Technology Conference, Paper No. 5006, Houston, May 1985.

Thank you for your support and guidance on this project. I hope you are pleased with the results.